Latent Heat Worksheet

1) What take more heat, melting or evaporating?

Evaporating

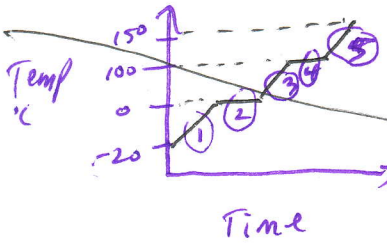
2) What type of substance has the lowest heats of fusion and heats of vaporization?

Metals

3) Why is water a good substance to use as a coolant in a car radiator?

High c, High H_v

4) How much heat is required to change 2.5 kg of water at 20.0 °C to steam at 150 °C?



(1) $Q = mc\Delta T$
$Q = 2.5\,kg\,(2100\ J/kg°C)(0-(-20°C))$
$Q = 105\,KJ$

(2) $Q_f = H_f m$
$Q_f = 334\,KJ/kg\,(2.5\,kg)$
$Q_f = 835\,KJ$

(3) $Q = 2.5\,kg\,(4200\ J/kg°C)(100°C - 0°C)$
$Q = 1050\,KJ$

(4) $Q_v = H_v m$
$Q_v = 2260\,KJ/kg\,(2.5\,kg)$
$Q_v = 5650\,KJ$

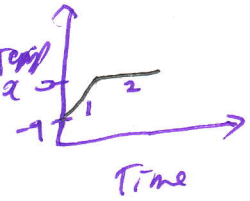
(5) $Q = mc\Delta T$
$Q = 2.5\,kg\,(2000\ J/kg°C)(150°C - 100°C)$
$Q = 250\,KJ$

See back

$Q_{Total} = 105\,KJ + 835\,KJ + 1050\,KJ + 5650\,KJ + 250\,KJ$

$Q_{Total} = 7890\,KJ$

5) How much heat is required to melt 6.0 kg of ice at -9.0 °C?



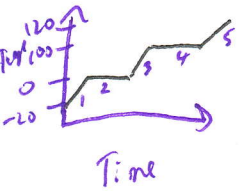
(1) $Q = mc\Delta T$
$Q = 6.00\,kg\,(2100\ J/kg°C)(0°C - (-9°C))$
$Q = 113.4\,KJ$

(2) $Q_f = m H_f$
$Q_f = (6.0\,kg)(334\,KJ/kg)$
$Q_f = 2004\,KJ$

$Q_{Total} = 113.4\,KJ + 2004\,KJ = 2117.4\,KJ \approx 2100\,KJ$

6) How much heat is needed to change 500 g of ice at -20 °C to steam at 120 °C?

$m = 500\,g = 0.5\,kg$



(1) $Q = mc\Delta T$
$Q = (0.5\,kg)(2100\ J/kg°C)(0 - -20°C)$
$Q = 21\,KJ$

(2) $Q_f = H_f m$
$Q_f = 334\,KJ/kg\,(0.5\,kg)$
$Q_f = 167\,KJ$

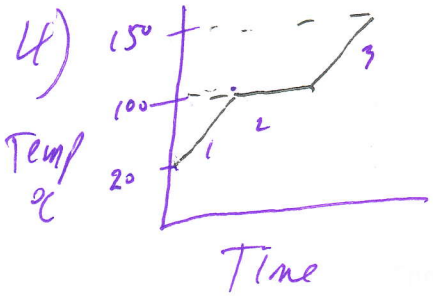
(3) $Q = mc\Delta T$
$Q = (0.5\,kg)(4200\ J/kg°C)(100°C - 0°C)$
$Q = 210\,KJ$

(4) $Q_v = H_v m$
$Q_v = 2260\,KJ/kg\,(0.5\,kg) = 1130\,KJ$

(5) $Q = mc\Delta T$
$Q = 0.5\,kg\,(2000\ J/kg°C)(120°C - 100°C)$
$Q = 20\,KJ$

$Q_{Total} = 21\,KJ + 167\,KJ + 210\,KJ + 1130\,KJ + 20\,KJ$

$Q_{Total} = 1548\,KJ$

4) 

① $Q = mc\Delta T$

$Q = 2.5\,kg\,(4200\,J/kg°C)(100°C - 20°C)$

$Q = 840\,KJ$

② $Q_v = mH_v$

$Q_v = 2.5\,kg\,(2260\,KJ/kg)$

$Q_v = 5650\,KJ$

③ $Q = mc\Delta T$

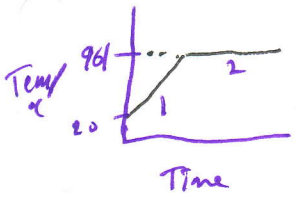
$Q = 2.5\,kg\,(2000\,J/kg°C)(150°C - 100°C)$

$Q = 250\,KJ$

$Q_{TOTAL} = 840\,KJ + 5650\,KJ + 250\,KJ$

$Q_{Total} = 6740\,KJ \simeq 6700\,KJ$

7) How much heat is needed to turn 2.0 kg of silver at 20 °C into a liquid? Silver melts at 961 °C.



① $Q = mc\Delta T$

$Q = 2.0\text{kg}\,(230\ \text{J/kg°C})\,(961\text{°C} - 20\text{°C})$

$Q = 432860\ \text{J}$

$Q \approx 430\ \text{KJ}$

② $Q_F = H_F m$

$Q_F = 10.4\ \text{KJ/kg}\,(2.0\ \text{kg})$

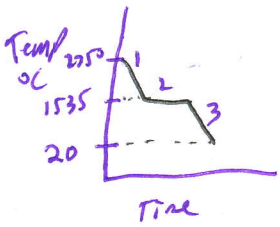
$Q_F = 20.8\ \text{KJ}$

$Q_F \approx 21\ \text{KJ}$

$Q_{Total} = 430\text{KJ} + 21\text{KJ} = \boxed{451\ \text{KJ}}$

8) How much heat is required to change 10.0 kg of aluminum at -40 °C into a liquid? Aluminum melts at 660 °C.

9) How much heat is released if 1.5 kg of molten iron is cooled from its boiling point, 2750 °C, to room temperature, 20 °C. The freezing point of iron is 1535 °C.



① $Q = mc\Delta T$

$Q = 1.5\text{kg}\,(460\ \text{J/kg°C})\,(1535\text{°C} - 2750\text{°C})$

$Q = -838350\ \text{J} \approx -838\ \text{KJ}$

② $Q_F = -H_F m$

$Q_F = -266\ \text{KJ/kg}\,(1.5\ \text{kg})$

$Q_F = -399\ \text{KJ}$

③ $Q = mc\Delta T$

$Q = 1.5\text{kg}\,(460\ \text{J/kg°C})\,(20 - 1535)$

$Q = -1045350\ \text{J}$

$Q \approx -1045\ \text{KJ}$

$Q_{Total} = -838\text{KJ} - 399\text{KJ} - 1045\ \text{KJ}$

$Q_{Total} = -2282\text{KJ} = \boxed{-2300\ \text{KJ}}$

10) How much heat is required to evaporate liquid carbon dioxide? Assume the carbon dioxide is at its boiling point.

11) How much heat would be required to melt 600 g of uranium?

$m = 600g = 0.6kg$

$H_f = 38.4\ KJ/kg$

$Q_f = ?$

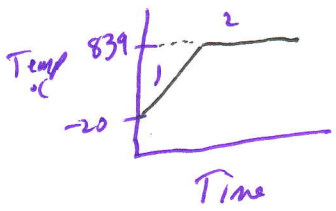
$Q_f = mH_f$

$Q_f = 0.6kg(38.4\ KJ/kg)$

$Q_f = 23.04\ KJ$

$\boxed{Q_f \simeq 20\ KJ}$

12) How much heat is required to change 250 g of calcium at -20 °C into a liquid at its melting point of 839 °C?

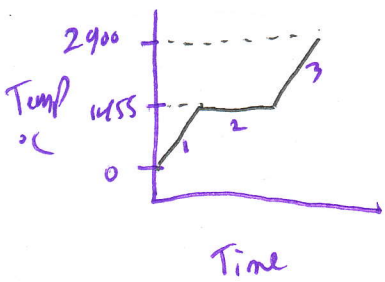


$m = 250g = 0.25kg$

① $Q = mc\Delta T$

$Q = 0.25kg($

13) Nickel melts at 1455 °C and boils at 2900 °C. How much heat is required to heat 350 g of nickel at 0 °C to its boiling point?



① $Q = mc\Delta T$

$Q = (0.350\ kg)(440\ J/kg°C)(1455°C - 0°C)$

$Q = 224070J \simeq 224KJ$

② $Q_f = mH_f$

$Q_f = 0.350kg(297\ KJ/kg)$

$Q_f \simeq 104\ KJ$

③ $Q = mc\Delta T$

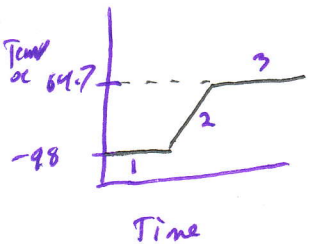
$Q = 0.350\ kg(440\ J/kg°C)(2900°C - 1455°C)$

$Q = 222530J \simeq 223KJ$

$Q_{Total} = 224KJ + 104KJ + 223KJ$

$\boxed{Q_{Total} = 551\ KJ}$

14) Methanol is the fuel used in some racecars. It has a melting point of -98 °C and a boiling point of 64.7 °C. How much heat is required to turn solid methanol at its melting point into vapour at its boiling point?



① $Q_f = mH_f$

$Q_f = 6.8\text{kg}(\text{10.9 kJ/kg})$

$Q_f = 74\text{kJ}$

② $Q = mc\Delta T$

$Q = 6.8\text{kg}(2500\text{J/kg°C})(64.7°\text{C} - (-98°\text{C}))$

$Q \simeq 2766\text{ kJ}$

③ $Q_v = mH_v$

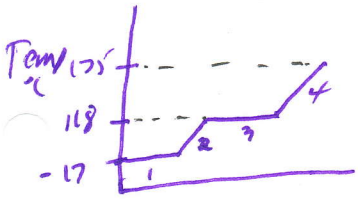
$Q_v = 6.8\text{kg}(878\text{ kJ/kg})$

$Q_v = 5970\text{ kJ}$

$Q_{Total} = 74\text{kJ} + 2766\text{kJ} + 5970\text{kJ}$

$Q_{Total} = 8810\text{kJ} \simeq (8800\text{kJ})$

15) Vinegar has a specific heat of 2052 J/kg °C as a liquid and 1117 J/kg °C as a vapour. How much heat would be required to change 750 g of solid vinegar at -17 °C into vinegar vapour at 175 °C? The boiling point of vinegar is 118 °C and a freezing point is -17 °C.



① $Q_f = mH_f$

$Q_f = 0.750\text{kg}(192.2\text{ kJ/kg})$

$Q_f = 144\text{kJ}$

② $Q = mc\Delta T$

$Q = 0.750\text{kg}(2052\text{J/kg°C})(118°\text{C} - (-17°\text{C}))$

$Q \simeq 208\text{ kJ}$

③ $Q_v = mH_v$

$Q_v = 0.750\text{kg}(695\text{ kJ/kg})$

$Q_v \simeq 521\text{ kJ}$

④ $Q = mc\Delta T$

$Q = 0.750\text{kg}(1117\text{J/kg°C})(175°\text{C} - 118°\text{C})$

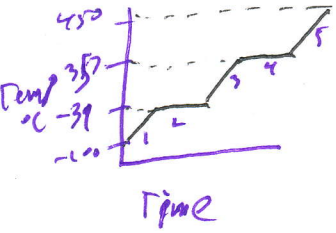
$Q \simeq 48\text{kJ}$

$Q_{Total} = 144\text{kJ} + 208\text{kJ} + 521\text{kJ} + 48\text{kJ}$

$Q_{Total} = 921\text{kJ}$

$Q_{Total} \simeq (920\text{kJ})$

16) The specific heat of mercury does not change much when it changes from a solid to a vapour. How much heat would be required to change 4.5 kg of mercury at -100 °C to vapour at 450 °C? The melting point of mercury is -39 °C and the boiling point is 357 °C.



① $Q = mc\Delta T$

$Q = 4.5\text{kg}(140\text{J/kg°C})(-39 - (-100))$

$Q \simeq 38\text{kJ}$

② $Q_f = mH_f$

$Q_f = 4.5\text{kg}(111.5\text{kJ/kg})$

$Q_f \simeq 52\text{kJ}$

③ $Q = mc\Delta T$

$Q = 4.5\text{kg}(140\text{J/kg°C})(357°\text{C} - (-39°\text{C}))$

$Q \simeq 249\text{ kJ}$

④ $Q_v = mH_v$

$Q_v = 4.5\text{kg}(272\text{kJ/kg})$

$Q_v = 1224\text{kJ}$

⑤ $Q = mc\Delta T$

$Q = 4.5\text{kg}(140\text{J/kg°C})(450°\text{C} - 357°\text{C})$

$Q \simeq 59\text{kJ}$

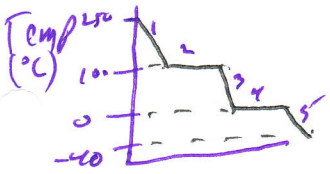
$Q_{Total} = 38\text{kJ} + 52\text{kJ} + 249\text{kJ} + 1224\text{kJ} + 59\text{kJ}$

$Q_{Total} \simeq 1622\text{kJ}$

$Q_{Total} \simeq (1600\text{kJ})$

17) How much heat is required to change 150 g of tungsten at 100 °C into a vapor at 6000 °C? Tungsten melts at 3410 °C and boils at 5660 °C.

18) How much heat is released when 500 g of steam at 250 °C is cooled to form ice at -40 °C?



(1) $Q = mc\Delta T$

$Q = 0.5\text{kg}(2000\text{ J/kg°C})(100\text{°C} - 25\text{°C})$

$Q \approx -150\text{ kJ}$

(2) $Q_v = -mH_v$

$Q_v = -0.5\text{kg}(2260\text{ kJ/kg})$

$Q_v = -1130\text{ kJ}$

(3) $Q = mc\Delta T$

$Q = 0.5\text{kg}(4200\text{ J/kg°C})(0\text{°C} - 100\text{°C})$

$Q \approx -210\text{ kJ}$

(4) $Q_f = -mH_f$

$Q_f = -0.5\text{kg}(334\text{ kJ/kg})$

$Q_f = -167\text{ kJ}$

(5) $Q = mc\Delta T$

$Q = 0.5\text{kg}(2100\text{ J/kg°C})(-40\text{°C} - 0\text{°C})$

$Q \approx -42\text{ kJ}$

$Q_{Total} = -150\text{kJ} - 1130\text{kJ} - 210\text{kJ} - 167\text{kJ} - 42\text{kJ} = -1699\text{kJ}$

$\approx -1700\text{kJ}$

19) A 2.5 kg piece of liquid gold at its melting point, 1064 °C, is placed on a 2.5kg block of ice at 0 °C. How much of the ice will melt?

20) What will release more heat, freezing 2.0 kg of carbon dioxide or evaporating 20.0 kg of helium? Assume both substances are at the proper temperatures for the changes of state to occur.

21) A 2.80 kg sample of platinum at 3500 °C is dropped into 1.00 kg of water at 0 °C. How much of the water will evaporate? The melting point of platinum is 1772 °C.

22) How much heat can be released by changing nitrogen gas at 25 °C into a solid? Nitrogen boils at -196 °C and freezes at -209 °C.

23) How much heat is released when liquid zinc cools from its melting point of 420 °C to 20 °C?

24) What is the final temperature of a mixture made from 3.0 kg of ice at -5 °C and 10.8 kg of copper at 2000 °C? The melting point of copper is 1083 °C.